

Land Application of Sewage Biosolids: Environmental Protection, Science, Policy and the Nutrient Management Regulation

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The Ministry of the Environment (MOE) and the Ministry of Agriculture, Food and Rural Affairs (OMAFRA) share responsibility for overseeing the framework for the application of nutrients on farmland. This framework minimizes risks to the environment and public health. Materials containing nutrients that come from off-farm sources are called non-agricultural source materials (NASM). These materials include fruit and vegetable peels, food processing waste, pulp and paper biosolids and sewage biosolids.

Spreading NASM on farmland returns nutrients and organic material to the soil. It allows the soil to breathe and hold nutrients and water, which decreases water runoff and soil erosion and increases overall water conservation. Soils that have good organic matter content are easier to work and plant roots can find water and nutrients more easily.

Ontario's requirements and policies for the land application of NASM were developed by policy experts, scientists and agrologists from MOE and OMAFRA. The ministries work with other jurisdictions to continuously review the latest science around the potential impacts to soil and groundwater from pathogens, metals and other contaminants. For example, in 2003, MOE and OMAFRA reviewed and confirmed the current nutrient application standards. In 2005, based on ongoing pathogen research, the ministries introduced an *E. coli* treatment standard into regulation as an indicator of pathogen reduction. The ministries are committed to continually reviewing and updating land application standards to reflect the most current relevant scientific research, available treatment technologies, and any new health information as it becomes available.

The latest 2009 revisions to the General Nutrient Management Regulation (O. Reg. 267/03) establishes consistent standards for NASM land application across the province. The standards focus on the quality of the material being land-applied requiring that the material meet strict criteria and be beneficial to the soil. These amendments have set recommended practices into regulation and apply to all fields where NASM is applied in Ontario. The use of land application plans, called NASM plans, will be required for certain materials. NASM Plans balance the amount of nutrients in the NASM with the nutrients required by crops, which limits the chance of excess nutrients impacting surface and ground water. In addition, NASM must meet newly established beneficial use criteria, which requires demonstration that the material will improve the growing of agricultural crops. The revised regulation also includes standards for odour which set additional setback distances from dwellings and other occupied buildings; the stronger the odour the greater the separation.

In the 2009 revisions to the General Nutrient Management Regulation the ministries have taken a risk-based approach dividing land applied material into three categories of NASM (1, 2 and 3) based on material quality. Category 1 includes plant-based materials which are inherently low in contaminants; Category 2 includes food processing materials which have a greater potential for contaminants; and Category 3 includes animal and treated human wastes which have inherently higher levels of contaminants and therefore have more stringent rules.

The Nutrient Management Regulation – Standards

Land application and material quality standards serve to minimize off-site migration of nutrients, pathogens and other contaminants to surface and groundwater. An overview of standards that are required by the Nutrient Management Regulation are discussed below.

Metal Standards

NASM contain many naturally occurring metals. Some metals, including zinc and copper, are micronutrients that are necessary for plant growth.

Eleven metals are regulated when NASM is applied to agricultural land. The eleven regulated metals are: arsenic, cadmium, cobalt, chromium, copper, mercury, molybdenum, nickel, lead, selenium and zinc. To protect plants and ensure against metal accumulation in soil there are strict limits on the metal levels in biosolids and soils, as well as maximum application loading rates based on a five year period. Soils receiving sewage biosolids must be tested at least every five years. Sewage biosolids cannot be land applied if the soils exceed regulatory limits or if the sewage biosolids exceed any of the regulated metal concentrations.

Pathogen Standards

Many microorganisms (bacteria, viruses and parasites) live naturally in the environment and are harmless to animals and humans. However, some microorganisms can cause illness if they are ingested by humans or other animals. These microorganisms are often referred to as “pathogens.” The province recognizes that sewage biosolids and some of the other NASM may contain pathogens. As a result, the ministries have developed new pathogen categories of material quality based on pathogen content. To meet the pathogen regulatory limits all raw sewage sludge must be treated to reduce pathogens prior to land application and sewage biosolids must be tested to indicate pathogen reduction. Treatment processes typically reduce *E. coli* and pathogens in raw sewage sludge by 90 to 99 per cent.

Nutrient Standards

Nutrients such as nitrogen and phosphorus are essential to crop production, but if improperly applied, can adversely impact soil and water resources. Excessive soil nitrate at the end of the growing season can leach into groundwater posing a risk to the environment and water quality. Phosphorus loading to surface waters from agriculture is an on-going water quality concern because excess phosphorus loadings to surface water can result in algae blooms.

To minimize the risk of over application of nutrients when land applying biosolids and to mitigate environmental degradation, the regulation requires that the application rate not exceed the agronomic rate. This means that there must be a balance between crop requirements, available land base and nutrients to ensure that the total available nutrients applied do not significantly exceed what the crop requires. Further, NASM Plans are required to account for any additional sources of nitrogen and phosphorus (manure or commercial fertilizers) that are applied in separate applications. Proper nutrient management planning is also in the best financial interest of farmers as it ensures the use of fertilizer is optimized.

In addition, the regulation restricts the land application of biosolids when the concentration of plant available phosphorus in the receiving soil is greater than 60 milligrams per litre of soil.

Other Standards

Waiting periods imposed by the regulation are intended to minimize the exposure of crops and animals to pathogens. Waiting periods allow for die-off of pathogens before crops can be harvested or animals can graze on the field.

Setback distances from residences, wells, surface water, bedrock and saturated soils have also been established to minimize risk to residents and the environment during and after land application.

Biosolids Research in Ontario

The ministries are committed to continually reviewing and updating land application standards to reflect the most current relevant scientific research and any new health information as it becomes available.

As part of this commitment to understand current research, the ministries keep abreast of new scientific findings and are actively involved in a number of studies investigating the presence and fate of various contaminants in sewage biosolids. Specific contaminant-related research is discussed below.

Pharmaceuticals and Personal Care Products

Sewage biosolids may contain trace amounts of a wide variety of substances from pharmaceuticals and personal-care products. These products include items such as soaps, shampoos and detergents and healthcare products. The ministries continuously review the latest science around the potential impacts to soil, groundwater and agricultural practices and are conducting a number of studies.

In collaboration with Agriculture and Agri-Food Canada, Health Canada, Trent University and OMAFRA, MOE examined the potential offsite movement of pharmaceuticals and personal care products from fields in Ontario that have received liquid municipal biosolids. It was determined that when liquid municipal biosolids were land applied by injection, the concentration of pharmaceuticals were not detectable in runoff waters. When biosolids were surface applied, pharmaceuticals were detected in the runoff in very low levels (parts per trillion range or nanograms per litre).

Currently, under the 2007 Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem, the MOE has ongoing studies in partnership with the federal government and research institutions reviewing best management practices. MOE is working in collaboration with Agriculture and Agri-Food Canada to further evaluate the persistence and fate of a selected group of organic compounds including pharmaceuticals, antimicrobial agents, personal care products such as fragrances and flame retardants from biosolids amended fields.

Other Contaminants

There are trace levels of other industrial and household chemicals in sewage biosolids. Research indicates that industrial organic contaminants such as organic acids, solvents and complex compounds, which can have adverse effects on public health and the environment, may volatilize or degrade quickly within treatment plants and in the soil after land application. Other research shows crop uptake of some of these chemicals is generally minimal as the compounds are too complex for uptake by root tissues. In addition, some of these compounds

bind tightly to soil particles, thereby reducing the risk of off-site movement and facilitating degradation.

A study by OMAFRA found no statistical difference in dioxins concentrations in soils that had received up to three applications of sewage biosolids that followed provincial requirements, and soils that had not received any.

Examples of published environmental studies that the ministries have been involved with are attached as Addendum 1.

Multi-stakeholder Collaboration

In addition to funding biosolids researchers directly, both ministries have collaborated in multidisciplinary research through formation and participation on multi-stakeholder science committees. Committees with a general focus on nutrient management practices that are applicable to both manure and municipal sewage biosolids are outlined in Addendum 2. Multi-stakeholder committees specific to non-agricultural source materials, including municipal sewage biosolids are discussed below.

Biosolids Utilization Committee - Through the Biosolids Utilization Committee, MOE and OMAFRA work with experts from other ministries and partners from inside and outside of government to provide guidance regarding the appropriate standards and policies related to the management of biosolids. The Committee includes representation from the Ministry of Health and Long-Term Care and local medical officers of health who bring health related concerns to the Committee's attention. BUC has also established subcommittees in which ministry and academic scientists, agronomists and engineers discuss detailed technical and health related topics.

The Water Environment Association of Ontario (WEAO) - WEAO is composed of a diverse group of stakeholders in the water and wastewater industry, completed a literature review study titled *Fate and Significance of Selected Contaminants in Sewage Biosolids Applied to Agricultural Land Through Literature Review and Consultation with Stakeholder Groups* (WEAO, 2001). The study was funded by MOE, Environment Canada and nine municipalities. The study found Ontario's biosolids regulatory standards are protective of public health and the environment and recommended that further research be conducted on pathogens, unregulated metals, pharmaceuticals and estrogenic hormones. The ministries are currently working with WEAO to revise the study.

Compliance and Enforcement

MOE's longstanding role in ensuring environmental protection through compliance and enforcement activities will continue with the revised regulation. Through proactive inspections and responding to reports of pollution or other incidents MOE will help ensure that materials are land applied according to provincial standards.

NASM land application standards and requirements are enforceable under the Nutrient Management Act, 2002, and if an adverse effect occurs or may occur, the Environmental Protection Act and the Ontario Water Resources Act may also apply.

Reporting Health Issues

Residents should report health complaints related to land application of biosolids to their local family doctor, Medical Officer of Health or public health unit, in the same way instances of animal illness should be reported to a veterinarian. The Medical Officer of Health will investigate such complaints and, where necessary, may refer the matter to, or investigate in collaboration with, MOE and/or OMAFRA. Once the investigation is finished, the Medical Officer of Health reports any findings back to the complainant.

Other Related MOE Programs

MOE recognizes the importance of properly treating wastewater to minimize the risks posed by the effluent and the biosolids to both public health and the environment. As such, the MOE continues to provide technical support to funding programs such as the Canada-Ontario Municipal Rural Infrastructure Fund, the Rural Infrastructure Investment Initiative, the Municipal Rural Infrastructure Investment Initiative and the Building Canada Fund.

These funding programs work to improve and renew public infrastructure across the province.

For example, funding from the Canada-Ontario Municipal Rural Infrastructure Fund was directed towards infrastructure improvements to provide clean, safe drinking water, better sewage systems, upgraded waste management processes, and safer roads and bridges.

The recent Building Canada Fund is sponsoring investments in wastewater infrastructure designed to, among other things, improve the management of biosolids and improve the quality of treated municipal wastewater effluent and storm-water discharged into the environment.

Through Ontario's Municipal Hazardous and Special Waste program household hazardous waste and other materials that require special handling are being diverted from landfills, waterways, sewers and wastewater treatment facilities. The Municipal Hazardous and Special Waste program commenced on July 1, 2008 and is industry managed and funded.

One of the main goals of the program is to decrease the amount of these wastes that enter our environment. This is achieved in part by enhancing consumer accessibility to waste diversion opportunities through increased municipal collection events and retail take back programs. The materials addressed by the program are common household products such as paints, solvents, antifreeze, fertilizers and pesticides. Other materials, such as pharmaceuticals, syringes and mercury containing products, including thermometers and fluorescent lamps, will be added to the program in future phases.

In addition, any potential agricultural threats to drinking water sources are assessed and considered by local source water protection committees, at the watershed and sub-watershed scale, as established and regulated under the Clean Water Act, 2006 and Technical Rules.

For more information on nutrient management and NASM, visit or call:

Ministry of the Environment
Public Information Centre
1-800-565-4923 or 416-325-4000
www.ontario.ca/nasm-moe

Addendum 1: Examples of MOE/OMAFRA-Supported Scientific Studies Relating to the Use of Biosolids

Surveys, Literature Review and Analytical Results for Biosolids:

1. WEAO literature review study titled Fate and Significance of Selected Contaminants in Sewage Biosolids Applied to Agricultural Land Through Literature Review and Consultation with Stakeholder Groups (WEAO, 2001)
http://www.weao.org/report/Fate_and_Significance.html
2. Field Survey of Polychlorinated Dibenz-p-dioxins and Polychlorinated Dibenzofurans (PCDD/Fs) in Sewage Biosolids Treated Ontario Agricultural Soils (OMAFRA, MOE and WTI. 1998) <http://www.omafra.gov.on.ca/english/nm/nasm/field/s98toc.htm>
3. Analytical Results, Findings and Recommendations of the 1995 OMAFRA Sewage Biosolids Field Survey (OMAFRA. 1995)
<http://www.omafra.gov.on.ca/english/nm/nasm/field/s95res.htm>
4. Biosolids Project (Golden Horseshoe Regional Soil and Crop Improvement Association. 2004) http://www.omafra.gov.on.ca/english/crops/field/news/croptalk/2004/ct_0304a5.htm
5. Unregulated Metals in Municipal Biosolids: Determinations of Sn and Tl. Hargreaves, J., Smith, P., Hale, B., Canadian Journal of Analytical Science and Spectroscopy. 2004, 49(2), 1-7.
6. 2003 MSc Thesis – The Development of a Method for the Analyses of Tin and Thallium in Biosolids and Their Determinations in Representative Ontario Biosolids. Jennifer Hargreaves, University of Guelph

Journal Articles and Proceedings on PPCPs in Sewage Treatment Plants

1. Runoff of pharmaceuticals and personal care products following application of biosolids to an agricultural field. Topp E., Monteiro S.C., Beck, A., Coelho B.B., Boxall A., Duenk P.W., Kleywegt S., Lapan D.R., Payne P., Sabourin L., Li H., Metcalfe C D. *Science of the Total Environment*, 2008.
2. Effect of Liquid Municipal Biosolid Application Method on Tile and Ground Water Quality, Lapan, D. R., Topp, E., Edwards M., Sabourin L., Curnoe W., Gottschall N., Bolton, P., Rahman, S., Ball-Coelho, B. Payne, M., Kleywegt, S., McLaughlin N. *Journal of Environmental Quality*, 2008, 37, 925–936.
3. Pharmaceutical and personal care products in tile drainage following land application of municipal biosolids, Lapan, D.R., Topp, E., Metcalfe, C.D., Li, H.X., Edwards, M., Gottschall, N., Bolton, P., Curnoe, W.E., Payne, M., Beck, A., 2008., *Science of the Total Environment*, 399, 50-65.
4. Sample Storage and Extraction Efficiencies in Determination of Polycyclic and Nitro Musk in Sewage Sludge; SA Smyth, L Lishman, M Alaee, S Kleywegt, L Svoboda, J-J Yang, H-B Lee and P Seto; *Chemosphere*, 2007, V. 67 pp 267-275.

5. Fate of Polycyclic and Nitro Musks during Aerobic and Anaerobic Sludge Digestion; SA Smyth, L Lishman, EA McBean, S Kleywelt, J-J Yang, ML Svoboda, H-B Lee and P Seto; *IWA Specialist Conference on Moving Forward Biosolids Sustainability*, June 2007, Moncton NB.
6. Polycyclic and nitro musks in Canadian municipal wastewater: occurrence and removal in wastewater treatment. Smyth, S.A., Lishman, L., McBean, E.A., Kleywelt, S., Yang, J.J., Svoboda, M.L., Ormonde, S., Pileggi, V., Lee, H.B., and Seto, P. *Water Quality Research Journal of Canada*, 2007, 42 (3), 138-152.
7. Seasonal occurrence and removal of polycyclic and nitro musks from wastewater treatment plants in Ontario, Canada. Smyth, S.A., Lishman, L., McBean, E.A., Kleywelt, S., Yang, J.J., Svoboda, M.L., Lee, H-B., and Seto, P. *Journal of Environmental Engineering and Science*, 2007, 7, 299-317.
8. Occurrence and Reductions of pharmaceuticals and personal care products and estrogens by municipal wastewater treatment plants in Ontario, Canada; L Lishman, SA Smyth, K. Sarafin, S Kleywelt, J. Toito, T Peart, H-B Lee, M Servos, M. Beland and P Seto; *Science of the total Environment*. 2006.

Journal Articles and Proceedings Related to the Land Application of Biosolids

1. Persistence associated with liquid swine manure and liquid municipal biosolids in repacked sand columns with artificial macropores. Rahman, S., Topp, E., Edwards, M., and Lapan, D.R. 2006. ASABE Paper number: 062194, 2006 *Annual International ASABE Meeting*, Portland Oregon, 11p.
2. Using MACRO to simulate liquid sewage biosolid transport to tile drains for several land application methods. Akhand, N., Lapan, D.R., Topp, E., Edwards, M., Sabourin, L., Ball Coelho, B., Duenk P., Payne, M. 2008. *Trans. ASABE*, 51, 1235-1245.
3. Potential of brilliant blue dye to inform timing of liquid biosolid application. Turpin, K.M., D.R. Lapan, M.J.L. Robin, E. Topp; M. Edwards, W.E. Curnoe, B. Ball-Coelho; N.B. McLaughlin; and M. Payne, 2007. *Biosystems Eng.*, 98, 235-247.
4. Prediction of liquid municipal biosolid and precipitation induced tile flow in a Southern Ontario agricultural field using MACRO. Akhand, D.R., Lapan, D.R., Edwards, M., Topp, E., Sabourin, L., Ball-Coelho, B., Duenk, P., Payne, M. 2006. *Agricultural Water Management*, 83, 37-50.
5. Pathogen Characterization of Fresh and Stored Biosolids and Implications of a Screening Level Microbial Risk Assessment. Flemming, C., Soller, J., Simhon, A., Seto E. 2009. Water Environment Federation Residuals and Biosolids conference, Portland, Oregon. May 2009.

Addendum 2: Examples of Multi-stakeholder Nutrient Management Committees – Multi-Disciplinary Research Collaboration

Committee Name	Purpose
<i>Provincial Nutrient Management Advisory Committee (PNMAC)</i>	The Provincial Nutrient Management Advisory Committee made recommendations for the implementation of regulations under the <i>Nutrient Management Act, 2002</i> . This was a 24-member advisory committee, drawn from a broad range of stakeholder groups, including farm organizations, the crop industry, the livestock industry, agribusiness, the pulp and paper industry, rural municipalities, the environmental community and the scientific and academic community.
<i>Nutrient Management Science-Based Standards Committee</i>	Following the work done by PNMAC, a team of six experts was formed in 2006 to work closely with the ministries with the mandate of advising on nutrient management measures that could be applied to all farms and would minimize negative impacts of agriculture on the province's surface and ground water resources. These recommended practices were intended to provide proactive risk minimization by implementation as guidelines, regulations or as BMPs (best management practices) and were based on a review of the currently available science.
<i>Nutrient Management Joint Research Programme</i>	In 2005, MOE and OMAFRA established the Nutrient Management Joint Research Programme, a collaborative research effort between the ministries and hydrologists, agrologists and soil scientists from Ontario's leading universities to conducted the needed research to provide the scientific basis for land application options of agricultural (manure) and non-agricultural source materials (biosolids) in agricultural settings. The Programme has outlined the scientific gaps in knowledge associated with the various aspects of land application standards for agricultural and non-agricultural source material and is completing a final report summarizing the state of the science and recommendations for effective management practices supported by new science in areas such as applications on slopes, setback distances, and tillage practices.